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ABSTRACT

The mission of science education in Kansas is to develop all students into lifelong learners who are reasoned decision makers, contributing to the international community. Included in this document are guidelines and standards for use by all those concerned to ensure that the aforementioned mission is realized throughout all schools in Kansas. This document is partitioned into the following sections: (1) "Student Outcomes"; (2) "Program Outcomes" that include grade level benchmarks in science; (3) "The Meaning of Science Communicate"; (4) "Integration of Science"; (5) "The Relationship of Social, Technological, and Scientific Issues"; and (6) the appendix which includes themes to connect science programs. (ZWH)

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ED 370 765

KANSAS

CURRICULAR STANDARDS FOR SCIENCE

Kansas State Board of Education
Outcomes Education Team
120 S. E. 10th Avenue
Topeka, Kansas 66612-1182

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Index

Mission Statement..... 1

Student Outcomes..... 4

Program Outcomes..... 5

The Meaning of Science Communicate..... 14

Integration of Science..... 16

The Relationships of Social, Technological, and Scientific Issues..... 20

Appendix: Themes Connect Science Programs..... 26

Bibliography..... 34

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SCIENCE STANDARDS

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Mission Statement for Science Education in Kansas

The mission of science education in Kansas is to develop all students into lifelong learners who are reasoned decision makers, contributing to the international community.

Statement of Philosophy

These are extraordinary times and the educational system must prepare the citizens of Kansas to meet the challenges of their future. Science education in Kansas is an essential component in the process of developing citizens to meet a challenging new world. Kansans are now required to interact and relate to people from various cultures in all parts of the globe as well as deal with an unprecedented explosion of information from which meaning and application must be constructed. Like peoples from all over the world, Kansans are faced with environmental, technological, economic and social problems on an unprecedented scale.

Science education in Kansas must undergo transformation. This transformation must be based upon the best that the current research base suggests. This base indicates the following characteristics need to be present in a transformed science program.

Teachers as well as students must:

- be challenged to become skillful thinkers and problem solvers.
- work together in groups and teams.
- be creative.
- value curiosity.
- persevere in long term investigation.
- communicate effectively.
- apply what they learn to authentic needs within their own communities.
- be flexible and adaptable to changes and discoveries.
- make the connections between the fundamental concepts of our natural world as well as between science, technology, and society.

In addition, science education in the state must be developmentally appropriate and utilize a systemic, progressive approach throughout the elementary, middle and high school years. It is time that teachers and students alike see themselves as lifelong learners and achieve the skills necessary to continually grow intellectually and professionally throughout their lives. This can only be accomplished if risk-taking, inquiry, and investigation, are valued human endeavors. It follows that science education must become far more than the traditional transmission of scientific facts and concepts from teacher to student.

These are the characteristics of a new vision for science education in the state of Kansas. It is the purpose of this document to clarify this vision further and to provide guidance for the K-12 science educators making the transformation.

Recommendations:

- It is the responsibility of each school district to determine the topics, skills and specific learning activities that will be taught in each grade and to establish a Pre-K-12 continuum with balance and articulation. This document will serve as a guide with benchmarks at grades 2, 5, 8, and 11 to fulfill this responsibility. State and local assessment will be developed on the basis of this document.

- Science curricula must be designed to meet the needs of all students regardless of gender, ethnic origin, or economic status.

- A major component of the science programs in Kansas will become the strengthening of problem solving skills.

- Conceptual themes will be incorporated into the curriculum in order that students understand the connections that make information manageable and useful.

- All other disciplines will be integrated with science and technology programs and science and technology will be integrated with other disciplines.

- Quality science curriculum will identify fewer concepts to be learned in greater depth.

- Constructivist, long term investigations should be incorporated into more science instructional strategies.

Characteristics of quality science instruction:

· Teaching consistent with the nature of scientific inquiry.

· Beginning concept development with questions, events, or phenomena that are interesting and familiar to students.

· Engaging learners actively.

· Using team approach and cooperative learning techniques.

· De-emphasizing lower level memorization skills and emphasizing the higher level thinking skills.

· Using multiple resources including supplemental materials, audio-visual aids, libraries, computers, telecommunications, multi-media, (technologies, materials and persons from the community), and science institutions.

· Generating science investigation from current issues and events.

· Insisting on quality communication.

· Concentrating on the collection and use of evidence.

· Coupling methods of science (doing) with scientific conclusion (knowing).

· Valuing respect, risk-taking, equity(gender and ethnicity), and inquiry in the classroom.

· Integrating community-based issues and problems as a part of instruction.

· Implementing safe practices.

Themes Connect Science Programs

The field of science is expanding at a dramatic rate with new knowledge being added and with an increasing number of new careers in the field. The rapid growth of science, engineering, and technology occupations shows the need for emphasizing the relationships among the various disciplines in science. These connections promote conceptual themes.

Identified themes include **Energy/Matter, Patterns of Change, Systems and Interactions, Stability, and Models**. The use of themes as organizers in the science curriculum can help to show how knowledge, principles, and concepts connect one science subject to another. These themes have direct applications in the earth, life, and physical sciences. The themes illustrate the relationships that exist between the divisions of science and emphasize the ways in which they are important in technology and affect societal questions. (The expanded themes and their definition can be found in the appendix.)

STUDENT OUTCOMES

STUDENT OUTCOME I

All students will demonstrate in academic and applied situations a high level of mastery of essential skills as evidenced by the following standards:

A. Read and comprehend a variety of resources.
B. Communicate clearly, both orally and in writing, for a variety of purposes and audiences.
C. Use mathematics and mathematical principles.
D. Access and use information

STUDENT OUTCOME II

All students will demonstrate effective communication skills as evidenced by the following standards:

A. Analyze, summarize, and comprehend what is read in all subject areas.
B. Write and orally communicate for:
   1. clear articulation,
   2. analysis,
   3. conceptualization,
   4. synthesis, and
   5. summarization of information.

STUDENT OUTCOME III

All students will demonstrate complex thinking skills in academic and applied situations as evidenced by the following standards:

A. Apply problem-solving skills.
B. Find information; process, analyze, and synthesize it; and apply it to new situations.
C. Use creative, imaginative, and divergent thinking to formulate and solve problems, and to communicate the results.

STUDENT OUTCOME IV

All students will demonstrate the necessary characteristics to work effectively both independently and in groups as evidenced by the following standards:

A. Work collaboratively in teams.
B. Work together without prejudice, bias, or discrimination, using techniques to separate people from problems, focusing on interests not positions, inventing options for mutual gain, and using objective criteria.

STUDENT OUTCOME V

All students will demonstrate physical and emotional well-being as evidenced by the following standard:

A. Have the knowledge, skills, and behaviors essential to live a healthy and productive life.

Program Outcomes

And Grade Level Benchmarks

*Examples are provided under selected benchmarks to clarify intent. These are meant only as **examples** to stimulate further thought about the student outcomes.*

The Nature of Science

- The processes of science provide a means for producing knowledge. Some of these processes are: observing, classifying, questioning, inferring, predicting, collecting and recording data, experimenting, relating, measuring, developing hypotheses, applying, using numbers, communicating, constructing models, interpreting data and identifying and controlling variables.

The Learner:

1. Applies problem solving skills.

Grade 2

Uses appropriate technology as a tool in problem solving.
(Examples: Uses a hand lens to study insects, balance to compare mass of fruits, computers to study science process through simulations, and calculators to assist with data)

Uses appropriate science process skills in problem solving.
(Examples of this outcome are found in the processes below.)

Observing

Makes observations without drawing conclusions.
(Example: States characteristics of leaves, shells, water, air, etc.)

Identifies physical characteristics of living or non-living objects by direct observation.
(Example: States that a rock is hard, cotton is soft and leaves have veins, etc.)

Uses instruments to aid in making observations.
(Example: Uses magnifiers, balance, scales, thermometers, measuring cups, spoons)

Classifying

Groups living and non-living objects by a variety of characteristics (e.g., color, shape, size).
(Example: Groups seeds by color, texture, size; objects float or sink; groups rocks by texture, color, hardness)

Orders objects by a characteristic.
(Example: Orders by darkest to lightest, smoothest to roughest)

Measuring

Orders or groups objects by inspection in terms of common measurable properties such as length, capacity, weight.
(Example: Places leaves in order from the longest to the shortest. Places in order containers of liquids from the smallest to the largest. Orders objects from heaviest to lightest)

Orders by an arbitrary measuring device.
(Example: Compares lengths to a stick of any given length)

Communicating

Describes an observation orally or pictorially.
(Example: Draws pictures of plant growth on a daily basis. Notes color, number of leaves in journal)

Gives a verbal description of an object so that another person is able to recognize that object.
(Example: Presents unique properties of a rock so that others recognize it from a group of rocks; e.g., The rock is black and white, smooth and as big as an apple)

Predicting

Uses observations already made to predict a future event.
(Example: Using unifix cubes to measure a plant's height, predicts the number of cubes for tomorrow's height)
(Example: Observes objects placed in water sinking or floating; then predicts similar objects as they are placed in water)

Grade 5

Uses appropriate technology as a tool in problem solving.

Uses appropriate science process skills in problem solving.
(Examples of the above two outcomes are found in the processes below.)

Observing

Describes complex objects by observing their essential characteristics.
(Example: Chooses three unique identifying characteristics of a rock, crayfish, seed, etc.)

Uses optical devices to improve visual observations.
(Example: Uses a variety of elementary optical devices to observe phenomena)

Verifies observations of the characteristics of living and non-living objects by examining several living and non-living things.
(Example: Uses characteristics of a tree to state reasons why it is alive or not alive. Using plants in the schoolyard or a prairie, observes similarities of living things. Looking at kitchen powders, describes likenesses and differences of non-living things)

Identifies objects within a system and their interactions.
(Example: Uses electrical circuits, rockets, furnace and thermostat, lists the objects in each system and identifies ways they interact. Uses the schoolyard as a system, lists the living and non-living objects and observes ways they interact)

Inferring

Identifies inferences during a hands-on experience.

(Example: Lists statements about a leaf and identifies which of the statements are inferences. Compares a block of wood and a block of plastic of the same size and infers the objects weigh the same)

Distinguishes inferences from observations.

(Example: Given a set of objects and statements about them, identifies statements which are observational facts from inferences. Observes the ground is wet and infers that it rained last night. Observes a mealworm is not moving and infers the mealworm is dead)

Classifying

Classifies items, by putting them together on the basis of more than a single characteristic at a time.

(Example: Groups all leaves with pointed edges and singular main vein into one group)

Predicting

Observes phenomena and makes predictions.

(Example: Observes an acid (like cream of tartar) is added to a base(like baking soda) in equal amounts, predicts that each time this is done the material remaining will be neutral. Observes the rate of a plant's growth in light and predicts another plant's growth rate in the same light. Counts the number of dandelions on the north side of the school building in the fall and predicts the number there in the spring)

Makes predictions based on recorded data.

(Example: Based on data collected on number of insect holes observed in the schoolyard, seeds in a pod, predicts the number there will be next week)

Uses data from graphs to make predictions.

(Example: Uses data from graphs to make predictions about plant growth, weather changes, human development, changes in matter, etc.)

Measuring

Practices measuring length, weight, and volume by comparison to a standard unit of measurement.

Uses a Celsius thermometer to measure temperature.

Uses a simple balance to measure mass in Kilograms.

Chooses the most appropriate unit and measuring device for a given observation.

(Example: Given a mealworm race, decides how to measure the distance)

Data Collecting/Record Keeping

Keeps record of observations in investigations.

(Example: Records height of a plant, weight of a mouse, development of a baby animal, results of mixing a series of powders in various combinations, etc.)

Uses data to describe what happened in the investigation.

(Example: Describes where the mealworm spends most of its time in a box by looking at the data)

Questioning

Formulates questions which can be answered by simple experiments.

(Example: Asks what would happen if an object is placed in a tub of water; asks how many paper clips will stick to a magnet; asks how an ice cube is kept from melting; asks how light affect a plant; asks what determines how high a ball bounces)

Relating

Relates new concepts to everyday environment.

(Example: Checks sugar content of cereals and evaluates which is the best choice. Classifies rocks as igneous, metamorphic, and sedimentary, and compares to the kinds of rocks in the local community)

Sees relationships between interacting objects.

(Example: Recognizes the relationship of light and water to the growth of a plant. Recognizes the plant's role in the world)
(Example: Relates what factors caused the event to take place. States examples of weather's effects on erosion. Compares the effects of poor nutrition on health. Relates the changing of animal's appearance with the seasons)

Grade 8

Integrates science process skills in problem solving.

(Example: Gathers weather data for two weeks; charts this data; makes a graph comparing dew point and relative humidity. Compares a small wheel and axle to a larger wheel and axle; determines which system has the greater mechanical advantage and explain why. Based on the knowledge of how plants produce starch, makes a hypothesis about the results for starch in a plant's leaves if it receives no light; conducts an experiment to determine if the hypothesis is correct.)

Evaluates the strengths and weaknesses of claims, arguments or data.

(Example: Evaluates a detergent, popcorn, soda, etc. claims with experimentation.)
(Example: Evaluates the claims made in news media, advertisements, and newspaper articles related to issues of interest to the student such as the effects of oil spills, effects of water or air pollution, dentistry, health issues, or local utility companies)

Generates scientific questions based upon observations.

(Example: Generates questions related to topics such as composting and fertilizers, sports injuries, environmental effects of industrial or population growth, humidity effects on hair, causes of stalagmites and stalactites, and discrepant events)

Designs and conducts simple investigations.

(Example: Designs and conducts investigations around questions such as the following: Does metal conduct heat better than non-metal? Does humidity affect the length of hair? What is the best method of separating salt from a sand-salt mixture? What factors affect the rate at which a sugar cube dissolves?)

Identifies and controls variables in experimentation.

(Example: Experiments with fertilizers and their effects on fast plants; identifies the effect of concentration of an acid on conductivity; determines variables affecting how fast objects fall through water; determines the variables affecting the distance or speed of a paper airplane)

Uses appropriate technology as a tool in problem solving.

(Example: Focuses microscope to observe life forms in a drop of river water; uses a computer for information gathering, data collection and analysis; uses a balance and graduated cylinder to determine density; uses maps and measuring instruments, such as a meter stick, compass, thermometer, and barometer)

Interprets the results of experimentation using statistical reasoning.
(Example: Calculates the mean, median, mode, and range of distribution of color and numbers in a bag of M&Ms; calculates the population of dandelions in a given area; or calculates temperature variation in a given year; develops line graphs, pie charts, histograms, stem and leaf plots, box and whisker plots)

Uses appropriate technology as a tool in problem solving.
(Example: Focuses the microscope to observe life forms in a drop of river water)

Grade 11

Uses science process skills in problem solving.

Identifies a problem or issue independently which can be investigated using scientific methodology.

Gathers and synthesizes information concerning a problem.

Generates and revises hypotheses.

Designs controlled experiments.

Interprets the results of experimentation using statistical analysis.
(Example: Analyzes central tendency, dispersion, correlation, and significance of experimental data)

Uses appropriate technology as a tool in problem solving.

2. Solves problems cooperatively.

Grade 2

Participates cooperatively in teacher-facilitated science activities.

Performs selected group roles and responsibilities.

Interacts positively with group members.

Grade 5

Participates in a science investigation team to resolve teacher-facilitated problem.

Expresses and receives support and acceptance with group members.

Performs selected group roles and responsibilities.

Grade 8

Participates in a science investigation team to resolve a student- and/or teacher-facilitated problem.

Expresses support and acceptance toward group members.

Performs and articulates selected group roles and responsibilities.

Identifies effective behaviors that contribute to successful group productivity.

Grade 11

Participates in a science investigation team to resolve a team-directed problem.

Restates or summarizes what others have said for clarification or elaboration and takes alternative perspectives.

Self-selects roles and responsibilities within groups and changes and assumes new roles to facilitate group success.

Evaluates group effectiveness and contributes to improved group dynamics.

3. Expresses creativity in problem solving.

Grade 2

Expresses a question in a way that it can be investigated.
(Example: The student asks, "What must I do to balance a card board shape on my finger after a paper clip is added?" or " Will the penny float?")

Grade 5

Designs and performs in groups or individually an experiment which can be tested.
(Example: Designs a test of wet strength in paper towels; experiments to control variables in plant growth; experiments on causes of soil erosion)

Grade 8

Designs and performs a controlled experiment to test an assigned problem.
(Example: Designs a controlled experiment to determine which of two media provide for the fastest growth of a yeast culture)

Grade 11

Designs an authentic project demonstrating problem-solving skills.
(Example: Conducts research and experimentation in an area of interest to the student)

4. Applies problem-solving skills to authentic, community-based issues.

Grade 2

Identifies problems in their environment and brainstorms solutions.
(Example: Brainstorms ideas to conserve the overuse of paper in the classroom)

Participates in the organization of a group-selected problem.
(Example: Identifies a littering problem around the school and determines with the group a solution; plans a trash-free lunch)

Grade 5

Conducts simple group investigations using community resources.
(Example: Conducts a survey of hazardous conditions in the home; e.g., hazardous wastes, smoke detectors, etc.)

Grade 8

Conducts research using community resources.
(Example: Identifies traffic problems in the community; interviews city officials and police to obtain information and data; suggests solutions to proper community officials; uses community plant life as bioindicators to monitor air quality (e.g., cupping redbud leaves indicate poor air quality); investigates grain storage and potential loses due to insects by interviewing grain elevator operators)

Grade 11

Conducts communitywide research and generates a product based upon scientific investigation. (Identifies an audience for the purpose of generating a product for them and soliciting feedback.)
(Example: Monitors local water quality; prepares reports to local or state officials; prepares manuals and brochures interpreting natural aspects of the local community; e.g., trails, birds, streams, architecture; teaches younger students in an activity format about environmental issues; participates in future planning for improving the quality of life in the community)

5. Demonstrates and values an inquiring attitude (as evidenced by curiosity, openness to new ideas, respect for reason, and a reliance on data, facts and observations, etc.).

Grade 2

Exhibits curiosity about the world.

Willingly participates in doing science.

Grade 5

Asks divergent questions and begins to investigate.

Approaches scientific experiences with self confidence.

Is open minded and willing to modify opinions based on evidence.

Grade 8

Considers alternative points of view.

Asks questions at a variety of levels (recall, comprehension, application, analysis, synthesis, and evaluation).
(Example: Asks questions, "What are the types of plastic packaging?{Recall}, What are the advantages of different types of packaging?{Analysis}, How can you design packaging which reduces the impact on the environment? {Synthesis}, Should we outlaw styrofoam packaging? Why?" {Evaluation})

Seeks evidence for conclusions.

Applies processes of science in personal decision-making.
(Example: Entertains hypothetical courses of actions and predicts the effects of each before making a decision)
(Example: Collects information on the advantages and disadvantages of using paper versus plastic to bag groceries; analyzes the effects of each on the environment; makes a recommendation to his/her family that they use canvas bags when they shop)

Grade 11

Critiques scientific experiments or research and identifies strengths or weaknesses.

Asks questions at a variety of levels (recall, comprehension, application, analysis, synthesis, and evaluation).
(Example: See eighth grade example)

Distinguishes questions that can be answered through investigation.

Seeks evidence to support point of view.

Assesses the results of one's own and other's work.

Applies processes of science in personal decision-making.

6. Exhibits safe and proper techniques for using instruments and materials of science.

Grade 2

Uses all objects safely.

Grade 5

Exhibits safe and appropriate techniques for using science equipment.

Grade 8

Uses simple measuring devices to make metric measurements.

Demonstrates laboratory safety.

Grade 11

Recognizes the limitations and accuracy of measuring devices.

Demonstrates precision in laboratory measurement.

Exhibits laboratory safety.

The Meaning of Science Communicated - *Receiving, interpreting, and giving information that has meaning.*

The Learner:

1. Receives and interprets meaning from information or observed phenomena.

Grade 2

Focuses attention and repeatedly observes.

Grade 5

Seeks information from objects and events for the purpose of asking investigative questions.

Recognizes not all data or observations are definite or complete.

Grade 8

Describes an object, event, process, procedure, or phenomenon using scientific terms.

Demonstrates the ability to follow written and oral directions.

Uses research skills in locating information from printed and electronic media and empirical observations.

Grade 11

Locates, reads, interprets, and constructs scientific information in symbolic form.

Applies research skills in locating information from printed and electronic media and empirical observations.

2. Communicates meaning to others using oral language, written language, mathematics, symbols, tables, graphs, visual aids, and technology.

Grade 2

Communicates characteristics of observed objects.

Grade 5

Communicates meaning by using oral, written, mathematical, and symbolic language (e.g., tables, graphs, visual aids and technology).

Grade 8

Communicates scientific understandings using oral language, written language, mathematics, symbols, tables, graphs, visual aids, and/or technology.

(Example: Verbal - Explains why increasing the number of light bulbs in a series circuit decreases the current flowing through them)
(Example: Written - In a journal, writes a paragraph summarizing thoughts about the word "greenhouse" and its relationship to climate)
(Example: Technological - Creates a hypercard stack of five cards using graphics to illustrate how electrical circuits work)
(Example: Using a pH probe and a computer, determines the pH of substances such as household ammonia, vinegar, tap water, dissolved alka seltzer, and lemon juice; makes a chart of the results)
(Example: Symbolic - Writes a formula relating "B" to "h" where "B" = height a ball bounces and "h" = height from which the ball drops)

Organizes and presents information and data in ways that others can understand it.

Describes an experimental process or procedure so that it can be replicated by others.

Grade 11

Communicates scientific understandings using oral language, written language, mathematics, symbols, tables, graphs, visual aids, and/or technology.

Assesses the effectiveness of own communications using feedback from an audience.

(Example: Student designs personal evaluation tool that an audience will use to assess the presentation)

The Integration of Science - *All the fields of science are interrelated with each other and with other disciplines. Themes are the conceptual organizations of accumulated knowledge within the science disciplines.*

The Learner:

1. **Explains and interprets theories and concepts in the life, earth and physical sciences using unifying themes, including, but not limited to Energy/Matter, Patterns of Change, Systems and Interactions, Patterns of Stability and Equilibrium, and Models.**

Systems and Interactions

Grade 2

Names parts in simple systems. (A group of objects interacting for a purpose. An interaction has taken place when two or more objects do something to each other and there has either been a change of properties, number of objects, or change in position.)
(Example: Names parts of plant system to include leaves, stem, root, water and perhaps flowers; when you add water to your plant system the plant will continue to grow; a pen, water and a paper towel could be part of a chromotography system; names parts of a playground, living and non-living. An aquarium system is made up of guppies, water, plants, snails)

Grade 5

Identifies the parts and interactions of natural systems. (A group of objects interacting for a purpose. An interaction has taken place when two or more objects do something to each other and there has either been a change of properties, number of objects, or change in position.)
(Example: Measures, records, graphs the frequency of occurrence of certain characteristics in a sample of objects - length of string of a pendulum, weight of the bob, height of the swing; weather, solar system, aquarium, school yard, prairie, whirly bird system, electrical systems, rainforest system, pulley system, systems a handicapped person uses)

Grade 8

Analyzes and connects systems and their interactions in the natural world.
(Example: Applies the concept of systems to weather, stars, hydrological cycle or aquarium; constructs systems that apply science concepts, i.e., electrical circuit, simple machines)

Grade 11

Evaluates the variables and interrelationships of systems.
(Example: Describes the position of the earth in relation to solar systems and galaxies; uses computer simulations to model gravitational effects; uses computers to construct models of atomic structure; uses computers, wind tunnels, or models to analyze the effects of variables on the performance of mechanical devices)

Uses analogies or metaphors to describe the operations of systems.
(Example: Describes the structure and function of a cell as compared to the structure and function of a city)

Energy and Matter

Grade 2

Classifies characteristics of matter.
(Example: Groups objects as solid, liquid or gas; classifies objects as living/non-living, will float/sink, hard/soft, light/heavy or smooth/rough)

Matches forms of energy with its source.
(Example: Matches a picture of a stove with the word heat)

Grade 5

Recognizes that interactions of matter and energy follow patterns of nature and are reproducible.
(Example: Recognizes the chemical properties of baking soda and vinegar are such that when they are mixed together, we say they interact; baking soda and vinegar mixed together interact the same every time; recognizes that food chains are an example of energy flowing through matter; explores the amount of energy required to move objects, e.g., a marble rolling down a ramp; identifies the source of energy and follows it through the system)

Grade 8

Understands that forms and interactions of matter and energy determine the nature of the environment.
(Example: Evaluates the effect of climate and environmental forces on different landscapes; explains weather changes in terms of interactions of masses of air at different temperatures and pressures)

Grade 11

Explains the scientific laws and theories relating to matter and energy.
(Example: Identifies how matter and energy are interrelated in the process of fusion; describes the consequences on the earth resulting from sunspots and solar flares)

Analyzes the movement of matter and energy through natural and man-made systems.
(Example: Traces the movement of matter and energy through a prairie ecosystem. Analyzes the movement of matter and energy through a power plant, roller coaster or other rides in an amusement park)

Patterns of Change (Trends, cycles, chaos)

Grade 2

Recognizes that change occurs in the natural world.
(Example: Recognizes sequence of growth states from baby to adult and seed to plant; identifies seasons and describes them; measures and describes the growth of organisms; identifies types of change. Observes schoolyard seasonally; observes day and night. Investigates which substances dissolve in water. Compares prehistoric animal characteristics with modern animal characteristics)

Grade 5

Describes cyclic changes in the natural world.
(Example: Identifies changes in an ecosystem. Describes how different materials affect the rate of electric current. Describes physical changes during human growth and development. Relates examples of how changing earth conditions have caused changes in biotic communities, water cycle, the life cycle of a mealworm or butterfly)

Observes and compares common characteristics of identified cycles.
(Example: Compares the likenesses and differences in the life cycles of butterflies and frogs)

Grade 8

Identifies patterns of change in the natural and technological world as trends, cycles, or chaos.
(Example: Examines a variety of changing earth conditions, chemical reactions, biotic changes as trends, cycles, or chaos. Traces the evolution of the automobile, airplane, etc. and identify patterns)

Grade 11

Analyzes the effects of variables on patterns of change (trends, cycles, or chaos [nonlinear dynamics]).
(Example: Explains how environmental changes impact species' survival. Intreprets evolutionary aspects of species development and adaptations. Analyzes the effect of human actions on environmental quality. Models how seasonal changes are related to the orbital changes. Analyzes the variables that affect flight)

Identifies how to manage a system through changing variables.
(Example: Changes environmental variables to manage successional change. Modifies the design of a vehicle to improve its efficiency)

Stability (Equilibrium, conservation, symmetry)

Grade 2

Classifies objects based upon properties of symmetry.
(Example: Classifies shapes that look the same from different directions, e.g., a round ball will look the same from every direction; a square will look the same from some directions; looks on the playground for symmetrical objects)

Grade 5

Demonstrates understanding of conservation of matter (totals stay the same, even if the things that make them up change).
(Example: Understands that a piece of paper could be made into something else, such as a tower or bridge; understands that a sugar cube is still sugar even though it can be crushed; understands that a piece of quartz rock is still quartz even if it is crushed into small pieces we call sand)

Demonstrates understanding of equilibrium (totals that stay the same because gains and losses are equal).
(Example: Understands concentrated food coloring will eventually move throughout the glass of water, even without stirring; understands a layer of cold water will mix with a layer of hot water)

Grade 8

Cites examples from the natural world of equilibrium.
(Example: Identifies examples of species that are dying at the same rate at which they are being reproduced)

Explains how matter and energy are conserved in natural phenomena.
(Example: Traces the energy transformations in a braking car)

Shows examples of how upset equilibriums can return.
(Example: Explains the population cycles resulting from changes in food supply)

Grade 11

Relates the return to equilibrium with the magnitude of change occurring.
(Example: Relates the amount or intensity of exercise with the time required to return to a heart rate measured before exercise)

Designs a system that demonstrates small scale changes within large scale equilibriums.
(Example: Builds a device to demonstrate the dynamics of the formation of a tornado; builds and tests a small thermostat)

Models (physical, conceptual, and mathematical)

Grade 2

Recognizes models differ from the real world.
(Example: Compares eye model to the real eye; compares a toy car to a real car)

Observes physical models to understand phenomena.
(Example: Uses a globe and a light bulb to model night and day)

Identifies models that are bigger than, smaller than, or the same size as the real objects.
(Example: Compares globe as smaller than the earth; compares a model airplane as smaller than a real plane)

Grade 5

Utilizes physical and conceptual models to represent phenomena.
(Example: Draws a simple food chain; constructs a model of a human lung from balloons and a plastic bottle; constructs a model of the water cycle. Constructs prototypes of space stations, rockets, earth-solar system, rainforest)

Grade 8

Describes the use of models in the workings of technology.
(Example: Describes how models are used in describing anatomical structure, bridges, construction of buildings, space craft, etc.)

Represents phenomena with physical, conceptual, and mathematical models.
(Example: Constructs models of linear and exponential growth. Describes the parts of a cell and their interactions in terms of an analogy such as that of a city and its parts. With simple materials, makes a hand-powered wheel and axle strong enough to lift a load of 10N using a much smaller force)

Explains rationale for using models.
(Example: Describes the advantage of an atomic model. Explains why engineers use models in wind tunnels)

Grade 11

Designs and constructs physical, conceptual, and mathematical models to represent phenomena.
(Example: Uses springs and balls to demonstrate wave and particle properties of light; builds spreadsheet simulations of population scenarios)

Evaluates the effectiveness of models in representing phenomena.
(Example: Analyzes the strengths and weaknesses of the particle/wave model of light; constructs a physical, or mathematical model and evaluates the strengths and weaknesses of the model's ability to predict phenomena)

The Relationships of Social, Technological, and Scientific Issues - *Science and Technology have complex interrelationships with social and physical environments.*

The Learner:

1. Applies reasoned decision-making skills to issues of personal and public concern.

Grade 2

Names careers that are related to science and technology.
(Example: Role plays a career that relates to science and technology; writes or illustrates about a career they would like to have which involves science and technology)

Lists ways in which science and technology can help people care for themselves and their health.
(Example: Brainstorms types of technology that help people to take care of themselves)

Grade 5

Recognizes that scientific knowledge, thinking processes, and skills are used in a great variety of careers.
(Example: Develops interview questions and then conducts an interview of a person involved in a scientific field (in a group or individually); writes up the interview and reports it to the class)

Recognizes that specific careers are not unique to gender, culture, or ethnicity.
(Example: Interacts with individuals in non-traditional careers)

Makes decisions related to personal health, nutrition and lifestyle based upon knowledge of scientific concepts.
(Example: Designs a week's menu for own family; this menu would include the latest recommended daily requirements for good nutrition; the student shops with the family to purchase foods and assists in preparation of the meals)

Grade 8

Explains how science, mathematics and technology apply in real world situations.
(Example: Describes the technology used to produce electricity)

Makes decisions related to personal health, nutrition and lifestyle based on knowledge of scientific concepts.
(Example: Consults with food service personnel and plans a balanced week-long lunch schedule for the school, based upon sound nutritional information)

Understands that science and technology can affect individual lifestyles.
(Example: Writes a paper describing what life would be like without a specific technological advance, e.g., electricity, computers, refrigerators, television, automobiles, etc.)

Recognizes science as a key component of many careers.
(Example: Prepares a concept map diagramming the fields of science that relate to a specific career)

Grade 11

Plans hypothetical career paths and identifies steps required to achieve them.
(Example: Researches the formal education and other requirements necessary to enter a particular career; writes letters to individuals in that career requesting information; writes letters to universities, trade schools, etc. requesting the program of required courses leading to specific degrees; constructs and presents to the class a diagram or flow chart showing the steps needed to reach the career goal)

Understands the scientific aspects of current issues.
(Example: Participates in a debate concerning the use of fetal tissue in medical procedures. Predicts the impact of future development of computer technology on the social and physical world)

Appraises and recommends public policy based upon scientific reasoning and risk assessment.
(Example: Prepares a letter to be mailed to a governmental representative explaining own position on the use of nuclear power for energy; the letter must include sound arguments based upon research and statistics)

Uses experiences with science and technology in personal decision making.
(Example: Writes a paper outlining a personal decision concerning own contribution to the protection of the environment; demonstrates personal action in implementing the plan described in the paper)

Debates the benefits and risks of new technologies on patterns of human activity.
(Example: Prepares an argument and debates the development of nanotechnology, the development of molecular machines and computers, genetic engineering, super conductivity, and cold fusion)

2. Analyzes how science and technology change our social and physical environment.

Grade 2

Explores the way things work.
(Example: observes inner-workings of toys and technological devices)

Invents a device to meet specific needs.

Recognizes that science and technology have changed over a long period of time.
(Example: Draws pictures representing the history of transportation with Columbus' ships and modern day supertankers. Draws pictures about living before electricity)

Recognizes that scientific contributions have been made by people of different genders, races, and ethnic groups.
(Example: Matches the scientific contribution with the person who developed that contribution)

Grade 5

Explores the structure and function of toys and other technological devices.

Invents a device to meet specific needs.

Explains scientific contributions made by people of different genders, races, and cultures.
(Example: Prepares an oral or written report on the contribution of a scientist of a different gender, racial or cultural group)

Traces historical developments in science and technology to contemporary counterparts.
(Example: Prepares a timeline or concept map tracing the history of the technology of travel)

Analyzes how technological developments affect leisure time.
(Example: Surveys and calculates the amount of time that three specific devices save within the home; these devices must contribute to the amount of leisure time available to the family)

Distinguishes between science and technology.
(Example: Studies the scientific concepts of magnetism and identifies the application of magnets used in the every day world. Explains the scientific concepts of simple machines and locates the applications of technologies in the home and community)

Grade 8

Invents a device to solve problems or meet specific needs.

Discusses the historical development of key scientific concepts and principles.
(Example: Participates in a panel presentation outlining what they believe to be the most important scientific discovery and the impact it had on the future)

Recognizes the contributions made in science by people of different cultures, gender, and ethnic backgrounds.
(Example: Prepares a multimedia or video presentation on the contribution of a scientist representing a different gender, race or culture. Interviews or corresponds with a person of a different gender, race, or culture who holds an occupation relating to science or technology; prepares a presentation on that interview or correspondence)

Understands that the developments of science and technology affect the condition of life.
(Example: Writes a report utilizing statistics on the positive and/or negative effects of the development of weapon technology on the quality of life)

Analyzes how imagination and society's needs influence scientific and technological advancements.
(Example: Reports on what imaginations and needs of men led to the development of flight, the automobile, motion pictures and computers; reports on future technologies that would meet a current need of people)

Grade 11

Forecasts the impact of scientific and technological advances on society and the physical environment.
(Example: Predicts the impact of future development of computer technology on the social and physical world)

Recognizes the contributions made in science by people of different cultures, gender, and ethnic backgrounds.
(Example: Interviews or corresponds with a person of a different gender, race, or culture who holds an occupation relating to science or technology; prepares a presentation on that interview or correspondence)

3. Evaluates the interrelationships between the beliefs of societies and the way in which science and technology are applied.

Grade 2

Evaluates the effect of man-made products on the environment.
(Example: Classifies packaging according to its impact on the environment. Chooses to pick up litter in own environment)

Grade 5

Recognizes that humans have an ecological impact on the equilibrium of the biosphere.
(Example: Describes the ecological impact of urban sprawl on the watershed and habitat)

Identifies the societal beliefs that affect the environment.
(Example: Analyzes the impact of automobiles on the environment. Identifies how beliefs about packaging affect the environment)

Grade 8

Explains interrelationships between research, technology, and society's responses.
(Example: Contrasts the research, technology and societal response to the technologies of fossil fuels vs solar energy)

Analyzes the ecological impact humans have on the equilibrium of the biosphere.
(Example: Prepares a presentation describing the destruction of ozone and the activities of man linked to that destruction)

Evaluates issues that relate to ecological responsibility.
(Example: Participates in a statewide water quality monitoring project)

Grade 11

Assesses the scientific aspects of current issues.
(Example: Analyzes the arguments for and against the continuation of the particle acceleration project)

Recognizes the limitations of science in addressing society's beliefs.
(Example: Describes the limitations of science in resolving the debate over pollution)

Analyzes and distinguishes those products and technologies which may have positive and negative outcomes for humans as well as the biosphere.
(Example: Analyzes and critiques the research, technology, and societal response to the human genome project or superconductivity)

Demonstrates ecological responsibility.
(Example: Develops a plan to reduce solid waste in the home or school)

Appendix

Themes Connect Science Programs

The field of science is expanding at a dramatic rate with new knowledge being added, and the number of new careers in the field are increasing. The rapid growth of science, engineering, and technology occupations show the need for emphasizing the relationships among the various disciplines in science. These connections promote conceptual themes.

Identified themes include Energy/Matter, Patterns of Change, Systems and Interactions, Stability, and Models. The use of themes as organizers in the science curriculum can help to show how knowledge, principles, and concepts connect one science subject to another. These themes have direct applications in the earth, life, and physical sciences. The themes illustrate the relationships that exist between the divisions of science and emphasize the ways in which they are important in technology and affect societal questions.

ENERGY/MATTER:

Energy is a central concept of the sciences because it underlies any system of interactions. Energy can be taught as a bond linking various scientific disciplines. Defined in physical terms, energy is the capacity to do work or the ability to make things move; in chemical terms, it provides the basis for reactions between compounds; and in biological terms it provides living systems with the ability to maintain their systems, to grow, and to reproduce.

Energy can be explored in various manifestations (heat, light, sound, electricity, and so forth), in conversions from one form to another. Energy is perhaps the most important theme to the physical sciences because all physical phenomena and interactions involve energy. Whether one discusses the energy of heat, light, sound, magnetism, or electricity, the conversions of energy from kinetic to potential or from electrical to heat or sound, or even the products formed by the combination of an acid and base, energy is involved.

The flow of the earth's energy comes from two sources. First, there are forces within the earth, fueled by nuclear reactions within the mantle and core, that translate through the crust and are responsible for the processes that drive mountain building, continental drift, volcanic eruptions, and earthquakes. Second, there are the forces on the surface of the earth, such as wind, precipitation, physical and chemical reactions, and the activities of living organisms (mostly driven by the sun's energy), that alter the face of the earth and are responsible for many geological processes.

The flow of energy through living things drives metabolism, growth, and development. The flow of energy through ecosystems determines how organisms interact through the trophic levels of communities. Because all life requires energy, biochemistry is really the study of how energy facilitates biochemical reactions that allow the body to synthesize biochemical molecules — the basis of growth.

The theme of energy is important to considerations of ethical behavior and the relationships of science and technology to society. Sources of energy on earth include solar, wind, and water power, geothermal energy, nuclear energy, and fossil fuels. Some sources of energy are virtually inexhaustible, such as solar, wind, water, and nuclear. Renewable sources, such as water power, can be recycled and replaced, while nonrenewable sources, such as fossil fuels, cannot be replaced. Students should appreciate these distinctions, the limitations of some sources of energy, and the need to conserve them or avoid their use.

Matter is the equivalent of energy. Physical, earth, and living systems are all composed of matter. The properties of matter such as mass, volume, inertia, density, texture, color, elasticity, and hardness all contribute to the understandable concepts of matter. Matter exists in four phases, solids, liquids, gases, and plasma. Solids, liquids and gases are all readily experienced on the surface of the earth in natural and man-made objects. Plasma is found in the structure of stars and in our sun.

The structure of matter—whether molecules, mountain ranges, or ecosystems—can generally be approached in several ways. One way is *reductionist*, a continuing search for the minutest levels of operation of natural phenomena. Research in the genetic code, the microstructure of cells, the lattice of a crystal, and the properties of neutrinos are all intended to explore the finest-scale workings of the natural universe. The complementary way to study the same natural phenomena is *synthetic*, in which all the levels of phenomena in a system are examined to see what roles they play in the overall behavior of the system. In a description of the structure of any system, both approaches are useful.

PATTERNS OF CHANGE:

Patterns of change are of particular interest because much of science is about how things evolve and how one change is related to another; much of technology is trying to control what changes occur. Descriptions of change are important for predicting what will occur; analysis of change is necessary for understanding what is going on, and predicting what will happen; and control of change is essential for designing technological systems. Change can be classified into three general categories: (1) changes that are steady trends; (2) changes that are cyclic; and (3) chaotic changes. A system may contain all three kinds of change occurring together, for example, the patterns of evolution.

Changes that occur in steady trends are not necessarily all steady in the same sense, but they do progress in one direction and have fairly simple mathematical descriptions. Examples include the velocity of falling objects in acceleration, the decay of radioactive material, and the colonization of offshore islands by continental plants and animals.

Cyclical changes can be defined as an interval of time during which a sequence or recurring sequences of events or phenomena are completed; they are characterized by the range in variation from a maximum to minimum, by qualitative

distinctions that appear and reappear, and so forth. Cyclical changes are often found in systems containing feedback mechanisms or where a system depends on the periodicity of another system (such as the life cycles of annual plants and animals, which are dependent on the earth's annual revolution). Cyclical changes are common to living systems. They include life cycles, seasonal cycles, biochemical cycles of nutrients, water, gases, and so forth, and the flow of energy and matter through food webs and food chains. In earth science cyclical changes include the various planetary cycles and their effects on seasons, tides, and weather, the rock cycle, the cycles of natural compounds such as water, minerals, and so forth, and the great geophysical tectonic cycles of mountain building, plate movement, and subduction, coupled with cycles of deposition, lithification, and erosion. In the physical sciences, cyclical phenomena include sound waves and ocean waves, feedback in electronic systems, and the action/reaction systems of chemistry, particularly cell chemistry.

Chaotic changes are those that manifest the natural unpredictability of systems. Random changes may occur in reaction to small changes in stable conditions; some, for example, may appear cyclical but actually are never repeated in exactly the same way. These include the motions and periodicities of planetary bodies, the predator-prey cycles of ecosystems, population cycles and the dynamic equilibrium of populations, and plant succession cycles. Some random patterns of change may be unpredictable in details but in a larger sense are very predictable, and these include the examples just mentioned. The percentage of heads in a long series of coin tosses is expected to be approximately 50 percent, but in a short series the fluctuation from this figure may be great. The toss of a single coin is considered such a randomly governed event that we use it, for instance, as an arbiter of fairness to assign the kickoff at the start of football games.

SYSTEMS AND INTERACTIONS:

Systems consist of matter, energy and information which interact with each other in complex ways. Natural systems may include solar systems, ecosystems, individual organisms, and chemical and physical systems. By defining the boundaries of a system, a study of the system and its parts and interactions is possible.

There are many kinds of interactions in systems. The components of an ecosystem (individual species) may interact through predation, competition, commensalism, mutualism, parasitism, or any number of other patterns. At any time, a single component of a system can be interacting in various ways. A deer in an ecosystem can be a herbivore, an item of prey for a carnivore, and a living system itself with many subsystems of life functions (circulation, respiration, digestion, and so forth).

To study systems, we generally focus on one or a few aspects of interactions at a time to avoid an overload of information. These interactions are commonly described in simplified terms as models. Models almost never simulate all the factors that are interacting, nor all the ways in which the factors interact, but they do provide a way of describing natural phenomena that are organized in systems.

Some aspects of systems can be studied in the language of technology: input and output. Air and fuel go into an engine, and mechanical energy, exhaust, and heat come out. Carbon dioxide, solar energy, and water react in a chloroplast to produce sugars, oxygen, energy, and heat in the photosynthetic system. The fruit, seeds, and oxygen that are the products of flowering plants are input for animals in the same ecosystem.

Feedback is an important feature of interaction in many systems. We are all familiar with the squeal from a loudspeaker as a microphone is placed too close to it, but some forms of feedback are not so immediate. If a deer population increases in an area one year it may overgraze its habitat. As a result the starvation rate may increase the next year, and the population may be reduced to its original carrying capacity. In turn, the abundance or condition of other organisms that depend on the deer for part of their biotic interactions as well as the entire system and its interactions are affected. (Obviously, there is a lesson here for human intervention and interaction with other living things.)

STABILITY:

Stability refers to constancy - that is, the ways in which systems do not change and why. The ultimate fate of many systems is to settle into a balanced steady state or a state of equilibrium. In such states all forces are balanced. It is important to distinguish between the state of equilibrium and the steady state. The former is typified by a person sitting on a step of a stopped escalator, the latter by a person walking down a moving escalator just as fast as the escalator moves upward. Equilibrium is rare in living systems because living systems are inherently dynamic. (What physicists call steady state is what chemists and biologists call dynamic equilibrium.)

There are several kinds of equilibrium. A system can be in static equilibrium, as when a rock rests at the foot of a cliff, or in dynamic equilibrium, where the surface appearance is steady but much action is occurring at underlying levels. An example is a dish of water and carbon dioxide in equilibrium. Equal numbers of water and carbon dioxide molecules are always escaping into the atmosphere and returning to the solution, yet observable concentrations and pressures remain in a steady state. Other examples are the cellular and metabolic homeostasis of an individual organism and species and populational densities in an ecosystem.

Stability is related to the idea that nature is predictable. Given a set of initial experimental conditions, results are expected to be replicable. Indeed, failure to obtain reproducibility begins an immediate search for uncontrolled variables. Science is based on observations and set in a testable framework of ideas. Scientific theories and laws usually remain fairly stable because they are based on consistent evidence.

There is only an apparent contradiction between the theme of stability and patterns of change. The different themes may be applied to different situations or to different parts of the same natural situation. For example, the apparent stability in the

composition of a lush tropical forest may mask constant change in its plant and animal populations. Students will learn to recognize these concepts, differentiate between them, and appreciate when it is appropriate to describe natural systems in these terms.

MODELS:

A model of something is a simplified imitation of it that we hope can help us understand it better. A model may be a device, a plan, a drawing, an equation, a computer program, or even just a mental image. Whether models are physical, mathematical, or conceptual, their value lies in suggesting how things either do work or might work. For example, once the heart has been likened to a pump to explain what it does, the inference may be made that the engineering principles used in designing pumps could be helpful in understanding heart disease. When a model does not mimic the phenomenon well, the nature of the discrepancy is a clue to how the model can be improved. Models may also mislead, however, suggesting characteristics that are not really shared with what is being modeled. Fire was long taken as a model of energy transformation in the sun, for example, but nothing in the sun turned out to be burning.

Physical Models

The most familiar meaning of the term "model" is the physical model—an actual device or process that behaves enough like the phenomenon being modeled that we can hope to learn something from it. Typically, a physical model is easier to work with than what it represents because it is smaller in size, less expensive in terms of materials, or shorter in duration.

Experiments in which variables are closely controlled can be done on a physical model in the hope that its response will be like that of the full-scale phenomenon. For example, a scale model of an airplane can be used in a wind tunnel to investigate the effects of different wing shapes. Human biological processes can be modeled by using laboratory animals or cultures in test tubes to test medical treatments for possible use on people. Social processes too can be modeled, as when a new method of instruction is tried out in a single classroom rather than in a whole school system. But the scaling need not always be toward smaller and cheaper. Microscopic phenomena such as molecular configurations may require much larger models that can be measured and manipulated by hand.

A model can be scaled in time as well as in size and materials. Something may take so inconveniently long to occur that we observe only a segment of it. For example, we may want to know what people will remember years later of what they have been taught in a school course, but we settle for testing them only a week later. Short-run models may attempt to compress long-term effects by increasing the rates at which events occur. One example is genetic experimentation on organisms such as bacteria, flies, and mice which have large numbers of generations in a relatively short time span. Another important example is giving massive doses of chemicals to laboratory animals to try to get in a short time the effect that smaller doses would

produce over a long time. A mechanical example is the destructive testing of products, using machines to simulate in hours the wear on, say, shoes or weapons that would occur over years in normal use. On the other hand, very rapid phenomena may require slowed down models, such as slow motion depiction of the motion of birds, dancers, or colliding cars.

The behavior of a physical model cannot be expected ever to represent the full-scale phenomenon with complete accuracy, not even in the limited set of characteristics being studied. If a model boat is very small the way water flows past it will be significantly different from a real ocean and boat; if only one class in a school uses a new method, the specialness of it may make it more successful than the method would be if it were commonplace; large doses of a drug may have different kinds of effects (even killing instead of curing), not just quicker effects. The inappropriateness of a model may be related to such factors as changes in scale or the presence of qualitative differences that are not taken into account in the model (for example, rats may be sensitive to drugs that people are not, and vice versa).

Conceptual Models

One way to give an unfamiliar thing meaning is to liken it to some familiar thing—that is, to use metaphor or analogy. Thus, automobiles were first called horseless carriages. Living "cells" were so called because in plants they seemed to be lined up in rows like rooms in a monastery; an electric "current" was an analogy to the flow of water; the electrons in atoms were said to be arranged around the nucleus in "shells." In each case, the metaphor or analogy is based on some attributes of similarity—but only some. Living cells do not have doors; electric currents are not wet; and electron shells do not have hard surfaces. So we can be misled, as well as assisted, by metaphor or analogy, depending on whether inappropriate aspects of likeness are inferred along with the appropriate aspects. For example, the metaphor for the repealed branching of species in the "tree of evolution" may incline one to think not just of branching but also of upward progress; the metaphor of a bush, on the other hand, suggests that the branching of evolution produces great diversity in all directions, without a preferred direction that constitutes progress. If some phenomenon is very unlike our ordinary experience, such as quantum phenomena on an atomic scale, there may be no single familiar thing to which we can liken it.

Like any model, a conceptual model may have only limited usefulness. On the one hand, it may be too simple. For example, it is useful to think of molecules of a gas as tiny elastic balls that are endlessly moving about, bouncing off one another; to accommodate other phenomena, however, such a model has to be greatly modified to include moving parts within each ball. On the other hand, a model may be too complex for practical use. The accuracy of models of complex systems such as global population, weather, and social integration is limited by the large number of interacting variables that need to be dealt with simultaneously. Or, an abstract model may fit observations very well, but have no intuitive meaning. In modeling the behavior of molecules, for instance, we have to rely on a mathematical description that may not evoke any associated mental picture. Any model may have some irrelevant features

that intrude on our use of it. For example, because of their high visibility and status, athletes and entertainers may be taken as role models by children not only in the aspects in which they excel but also in irrelevant—and perhaps distinctly less than ideal—aspects.

The Science Processes

The processes of science are skills that are essential to developing knowledge, concepts, and application across the curriculum. The processes are often referred to as the "hands-on" approach to science and must be used throughout the program. Each of the terms has been adapted from Elementary Science Studies, American Association for the Advancement of Science, and Science Curriculum Improvement Studies and implies active student participation.

OBSERVING: Using the senses to gather information about objects and events in the environment. This skill includes using scientific instruments to extend the range of the human senses, and the ability to differentiate relevant from non-relevant events.

CLASSIFYING: A method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change. The test for a good classification system is whether others can use it.

MEASURING: A procedure for using instruments to determine the length, area, volume, mass, or other physical properties of an unknown quantity. It requires the proper use of instruments and the ability to calculate the measured results.

USING NUMBERS: This skill includes: number sense, computation, estimation, spatial sense, and whole number operation.

COMMUNICATING: Transmitting the results of observations and experimental procedures to others through the use of such devices as graphs, charts, tables, written descriptions, telecommunications, oral presentations, etc. Communication is fundamental to science, because it is in exchanging ideas and results of experiments that knowledge is validated by others.

QUESTIONING: The formulating of original questions based on observations and experiences with an event in such a way that one can experiment to seek the answers.

RELATING: In the sciences information about relationships can be descriptive or experimental. Relationships are based on logical arguments that encompass all data. Hypothetical reasoning, deductive reasoning, coordinate graphing, the managing of variables, and the comparison of effects of one variable upon another contribute to understanding the "big" ideas of science.

INFERRING: An inference is a tentative explanation that is based on partial observations. Available data are gathered and an evaluation is made based on the observed data. These judgments are never absolute and reflect what appears to be the most probable explanation at the time and are subject to change as new data is accumulated.

PREDICTING: Using previously-observed information to make possible decisions about future events.

FORMULATING HYPOTHESES: Stating a probable outcome for some occurrence based on many observations and inferences. The validity of the hypothesis is determined from testing by one or more experiments.

IDENTIFYING AND CONTROLLING VARIABLES: Determining what elements in a given investigation will vary or change and what will remain constant. Ideally scientists will attempt to identify all the variables before an investigation is conducted. By manipulating one variable at a time they can determine how that variable will affect the outcome.

COLLECTING AND INTERPRETING DATA: The information collected in order to answer questions is referred to as data. Interpreting data includes using information to make inferences, predictions, and form hypotheses. This includes developing skills in communicating statistical statements about the data in the form of mode, mean, median, range, and average deviation.

EXPERIMENTING: This process is the culmination of all the science process skills. Experimentation often begins with observations which lead to questions that need answers. The steps for proceeding may include forming a hypothesis, identifying and controlling variables, designing the procedure for conducting tests, implementing the test, collecting and interpreting the data, and sometimes changing the hypothesis being tested.

APPLYING: The process of inventing, creating, problem-solving, and determining probabilities are applications of using knowledge to discover further information.

CONSTRUCTING MODELS: Developing physical or mental representations to explain an idea, object, or event. Models are usually developed on the basis of acceptable hypotheses.

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Strategic Directions for Kansas Education

The Kansas State Board of Education is charged with the general supervision of public education and other educational interests in the state. While clearly acknowledging the role and importance of local control, the State Board of Education has the responsibility to provide direction and leadership for the structuring of all state educational institutions under its jurisdiction.

The beginning place for determining the mission for the Kansas State Board of Education is the assumption that all Kansas citizens must be involved in their own learning and the learning of others. It is the combined effort of family, school, and community that makes possible the development of a high quality of life. It is the parent who is the first "teacher" of children. As we grow older, we learn that the school, the workplace, and the community support our lifelong learning and our training and retraining. The Board recognizes the responsibility it holds for Kansas educational systems and promoting quality education programs. The mission for Kansas education is:

To prepare each person with the living, learning, and working skills and values necessary for caring, productive, and fulfilling participation in our evolving, global society.

We believe that the strategic directions for the structuring of Kansas education must be organized to:

- create learning communities
- develop and extend resources for parenting programs and early childhood education
- expand learner-outcome curriculum and learner-focused instruction
- provide inclusive learning environments
- strengthen involvement of business and industry in education
- provide quality staff and organizational development.

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The Kansas State Board of Education does not discriminate on the basis of sex, race, color, national origin, disability, or age in admission or access to, or treatment or employment in, its programs or activities. Any questions regarding the Board's compliance with Title VI, Title IX, or Section 504 may be directed to the Title IX Coordinator, who can be reached at (913) 296-3434, 120 S.E. 10th Avenue, Topeka, Kansas 66612-1182, or to the Assistant Secretary for Civil Rights, U. S. Department of Education.

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